SPACE SCIENCES LABORATORY

PART III

ON BEING INFORMED BY A COMPUTER-BASED MANAGEMENT INFORMATION SYSTEM: A STUDY IN INVOLVEMENT AND APPRECIATION

by

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UNIVERSITY OF CALIFORNIA, BERKELEY

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Chapter 3. Management Information Systems: A Reconsideration

> ...One should never lose sight of the fact that information is an incomplete concept. Whether it informs and, if so, what meaning it conveys, depends on the organization of the participants in the network in which it is used; and this organization is in turn developed by participation in the network.
>
> Sir Geoffrey Vickers [39 : 171]

The completion of our field study calls for a re-examination of the theoretical ideas presented in Chapter 1. In the first section to this chapter we undertake this task.

The second chapter section looks ahead toward "future research directions," and a third (and final) section casts a reflective glance backward, in an integrative assessment of our research experience.

3.1 MIS Understanding, Appreciation and Involvement: An Elaboration.

Our study of SQC Engineering and its information system was inconclusive with respect to the origins of MIS appreciation and involvement. Although appreciation was found to "explain" involvement, it did not explain the form of involvement. Nor did it explain itself.

Our initial model (Illustration 1.2) was found to be deficient in that an independent variable (manipulating factor) had not been specified.[1/]

However, our study has also revealed the importance of interpersonal involvement in the design and use of information systems. Hence it seems plausible that an extension of the model -- from intrapersonal to interpersonal form -- would offer the explanation desired. In this section we take steps in this direction.

First, we will revise the basic model to include additional cognitive variables. In doing so we seek to identify those factors which will precipitate MIS involvement, given an MIS understanding and appreication. We are guessing here that actual involvement will be co-produced by the origination of particular cognitions within the context of a relatively stable level of understanding and appreciation. The latter prepares the individual for involvement based on these cognitive events.

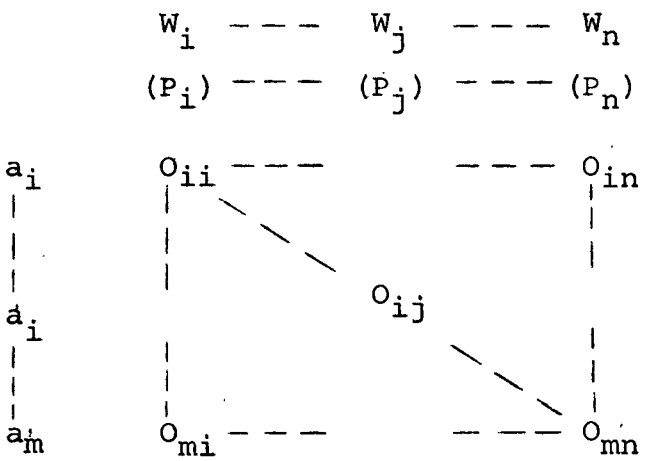
1/ Initially, "a priori involvement" was thought of as the independent variable, but this was a poor choice inasmuch as it represented involvement freely chosen (based on one's own appreciation) and not directly manipulatable.

We will assume that the originations of problem situations constitute the precipitating events. That is, the individual sees himself as faced with a choice among alternative courses of action. Thus, we need to identify the types of problems which will co-produce MIS involvement. Since statistical decision theory[1/] offers a well-defined treatment of problem situations, it may be helpful to examine the situations from this vantage point.

A decision-theoretic approach begins with an a priori statement of the problem in the following form. A manager is presumed to have a set of alternative actions a_1, ---, a_m from which he must choose one. The outcome of any action is subject to the influence of an unknown state-of-the-world from a set of possibilities W_1, ---, W_n. The uncertainty of the state-of-the-world is represented by a set of probability estimates p_1, ---, p_n.[2/] The potential outcomes O_{ij} are measured in terms of their relative preference (utility) to the decision maker (or client). Thus a decision problem may be represented as:

1/ For an excellent introduction, see Raiffa. [32]

2/ Where $\sum_{j=1}^{n} p_j = 1$.



For any decision problem of the above type a "maximum expected utility" may be computed, and a "best" choice is thereby identified. We might imagine an MIS inquirer to be confronted with this type of decision problem.[1/]

Extensions of decision theory into "information economics"[2/] provide insights into the use of information in decision making. Suppose, for example, that a manager has the option of conducting an "experiment" before resolving his basic decision problem. The results of the experiment will constitute a "message" (report) r_u from a set of possibilities r_1, ---, r_s. This report may "inform" the manager about the uncertain state-of-the-world in the sense of revising his

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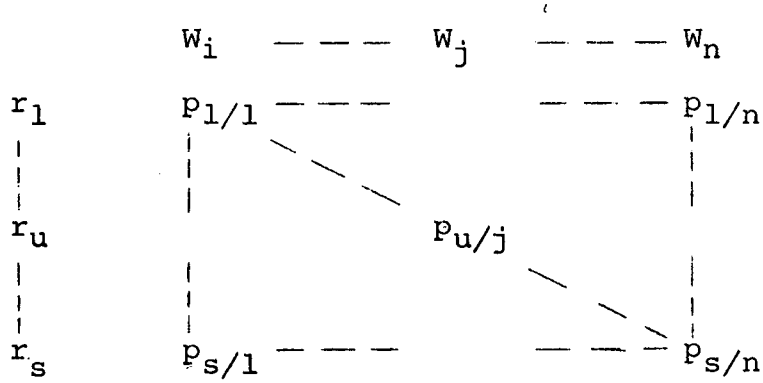
1/ An unrealistic assumption, psychologically, but useful in enabling us to structure our thinking about problem situations relating to MIS involvement.

2/ The primary work in this field is that of Marschak. (See Bibliography.)

probability estimates. In order for this to be possible, the manager must possess an a priori knowledge of the following form:



where $p_{u/j}$ represents the conditional probability of occurrence of a report r_u given a state-of-the-world W_j.[1/]

Knowledge of the above form constitutes knowledge of an information structure[2/] in the terminology of information economics. If the results of experimentation are statistically dependent upon the unknown state-of-the-world, it can be shown that experimentation will enable the manager to increase the maximum expected utility associated with his decision problem, in the long run.[3/]

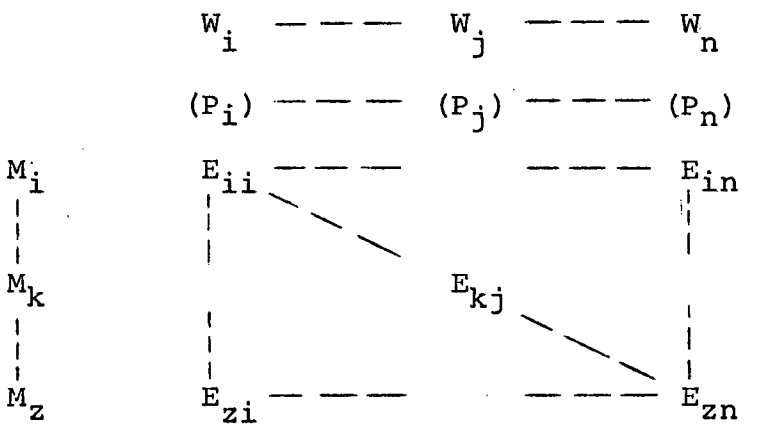
1/ And where $\sum_{u=1}^{s} p_{u/j} = 1$.

2/ Marschak. [28 : 86] Other terms have also been used, e.g. "inquiring function." [29 : 7.1]

3/ Ignoring the costs of experimentation. See Marschak. [27 : 201]

If we apply the above concepts to our inquirer-at-the-terminal we see that his experimental problem is the choice of a query q from a set of possibilities q_1, ---, q_t. Each query represents an alternative experiment. And each query is associated with an information structure of reports on the state-of-the-world. Thus our manager has an inquiry problem in addition to his basic decision problem. The inquiry problem is resolved by selecting the query associated with the information structure yielding the greatest increase in expected utility, over the long run. Thus we have an interpretation of what it means to "ask the right question."

Knowledge of a third type of problem is also relevant to MIS involvement. The designers of the MIS have their own problem type: the selection of a design alternative M_k from a set of possibilities M_1, ---, M_z. The implementation outcome of a choice will similarly be dependent upon the uncertain state-of-the-world. This design problem may be represented in the form:



where E_{kj} is a measure of effectiveness of design M_k given a state-of-the-world W_j.[1/]

An example of an MIS design problem is the choice of a query language. The outcome of a language choice is, of course, uncertain, in terms of implementation costs as well as user acceptance.

All three problem types are structurally non-separable. As we have already seen, the resolution of an inquiry problem is based on the decision problem which it supports. Similarly, the effectiveness of an MIS design must be thought of in terms of its implications for managerial inquiry and decision making. For example, the effectiveness of a query language depends upon its usefulness (utility) to an inquirer. The utility of inquiry must, in turn, originate with managerial decision problems.

1/ The partitioning of the states-of-the-world is not necessarily the same for the design and decision problems.

Thus, the cognition of one problem type should facilitate (and be facilitated by) the cognitions of the others.

We may summarize the conceptual results of our exercise as follows:

(3.1) An individual may possess three types of interrelated problem-situation cognitions relative to an MIS: (i) a decision problem, the choice between alternative courses of managerial action; (ii) an inquiry problem, the choice between alternative MIS queries; (iii) a design problem, the choice between alternative MIS designs.

The above cognitive variables are incorporated into our model of individual involvement in Illustration 3.1 on the following page.

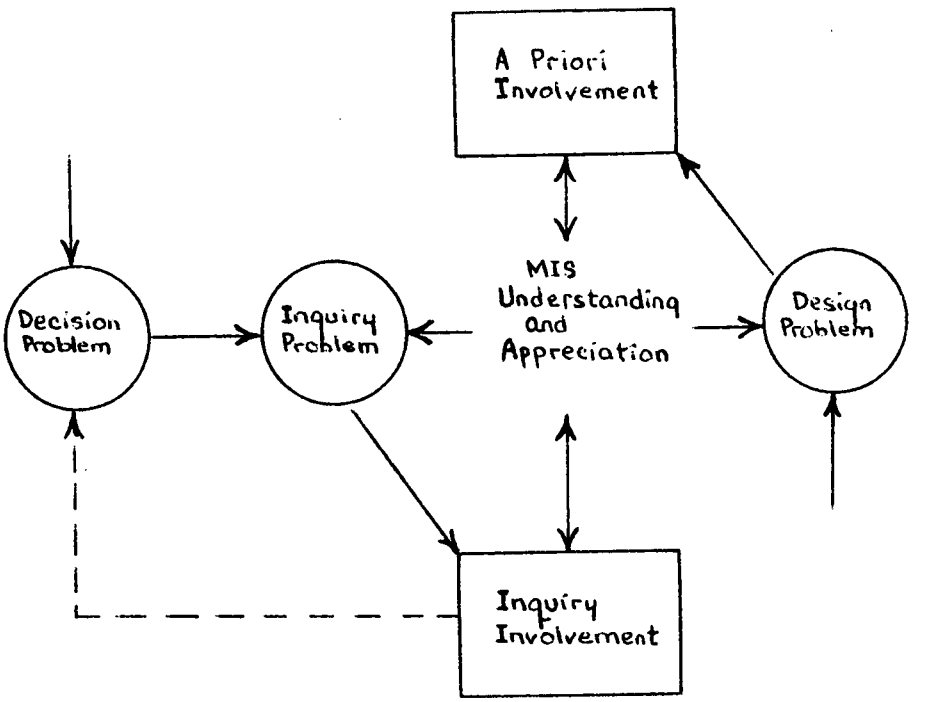


Illustration 3.1

A Revised Model of Individual

Involvement and Appreciation

The important conjectures associated with the relationships postulated in our model are the following:

(3.2) Inquiry involvement is co-produced by the cognition of a particular inquiry problem, given an MIS understanding and appreciation.

(3.3) The cognition of an inquiry problem is co-produced by the cognition of a particular decision problem, given an MIS understanding and appreciation.

(3.4) A priori involvement is co-produced by the cognition of a particular design problem, given an MIS understanding and appreciation.

Our revised model offers an explanation of the form of an individual's MIS involvement. An "inquirer" will be one who is confronted with decision problems which co-produce inquiry problems. A "designer" will be one who is faced with a series of design-problem situations. And the way in which our model can be extended to an interpersonal form is now clear: decision problems and design problems may be initiated through interpersonal communications. (The informal results of our study in the previous chapter suggest exactly this.) More specifically, the MIS involvement of one individual may generate decision and design problems for another, and hence lead to his involvement as well.

We have described two forms of MIS involvement, and two types of problem situations which may be externally induced. Thus there are four (2 x 2) types of interpersonal involvement-problem relationships, and these are identified in Illustration 3.2 on the following page. An example of each (based on the research of the previous chapter) will illustrate the possibilities:

I. An MIS proponent seeks to motivate user inquiry. He challenges certain managers to justify their budget requests with "back-up data" accessible via the MIS. The managers, faced with the decision problem of how to respond, then seek to reduce the uncertainty associated with the approval of their requests by means of MIS inquiry.

II. An MIS user decides a new report format would be preferable to the one currently being employed. He requests a modification to the MIS design to accomplish this.

III. An MIS user is "browsing" through the data base. He discovers a variance between planned and actual performance which is "unexplained." He writes a memorandum to the manager responsible, requesting an

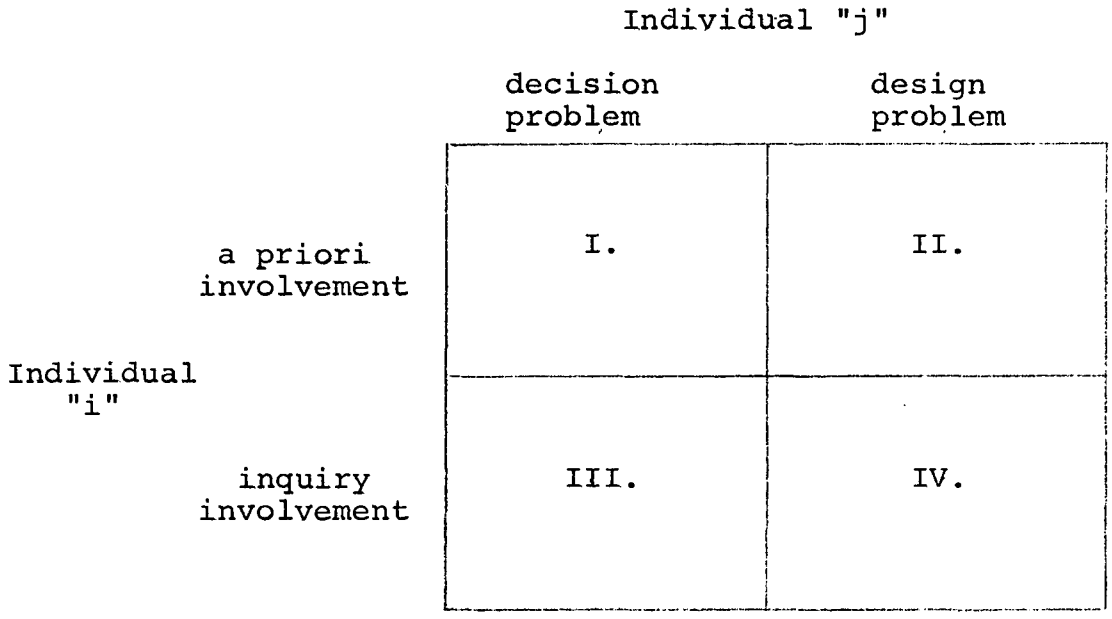


Illustration 3.2

A Typology of Interpersonal

MIS Involvement

(The involvement of individual "i" co-produces a problem cognition for individual "j". See text for examples.)

explanation. The manager, with access to more detail within the data base, engages in MIS inquiry to uncover the reasons for the variance.

IV. An MIS user addresses a query to the MIS which is misinterpreted, producing an unintelligible report. The user seeks an explanation from the MIS designer, who diagnoses the error and formulates a design modification to correct the situation.

Summarizing our discussion of interpersonal MIS involvement:

(3.5) The cognition of a decision or design problem by one individual is co-produced by the inquiry or a priori involvement of another.

This completes our reformulation of MIS theory based on the results of the previous chapter. With the above concepts in mind, we can address the question of future research needs.

3.2 Future Research Directions.

A replication of our field study is the most obvious "next step" for research on the concepts presented in this thesis. Our sample of a single MIS is hardly sufficient for confident generalization.

The next MIS to be studied should represent a contrast to the one presented here. The danger in our initial conclusions lies in their potential peculiarity to the organizational and technological environment from which they were drawn. Thus a strong contrast offers the best test of their generality.

A replication study should also make methodological improvements over this first effort. One such improvement would be the establishment of a more discriminating measure of "a priori involvement." The items in our questionnaire were relatively crude in application, and, in fact, the index finally used was an ad hoc modification of the one planned.

A second study could also utilize our revised model of individual involvement (Illustration 3.1), and test the additional hypotheses (3.2, 3.3, 3.4) raised in the previous section. In order to carry this out, the "problem situation" concepts (3.1) would have to be operationally defined; i.e. measurement criteria would have to be established.

Finally, it might be desirable, in a replication study, to move from purely observational research to some form of experimentation. The basis for this has been established with our conclusion (3.5) that problem-provoking activity by one individual can motivate the inquiry activity of another. Thus, an experimentor could engage in various problem provocations, and attempt to measure their impact on MIS inquiry and organizational decision making.[1/]

A follow-up study of ARIS would also be useful. Such a study could extend the "evolutionary perspective" of Section 2.3, and place our present research within this context. It might also be possible to experiment with organized question-raising, not as a tactic to stimulate ARIS inquiry, but as a method for identifying and ordering the important problems of SQC Engineering. The overt definition of these problems could place the relative utility of ARIS as a means of inquiry in a proper perspective.

In the long run, it will be necessary to extend our own locus for the study of management information systems, and to include organizational decision processes within this framework. The present research has

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1/ An interesting possibility here would be use of Mason's counter-planning technique [30] as the method for problem provocation.

concentrated on MIS appreciation and involvement, and has largely neglected the ongoing decisions the system purports to serve. In doing so, we have been opportunistic with respect to formal data gathering, using the MIS/360 Inquiry History Log to measure ARIS use. But this is a limited approach indeed, and it would obviously be desirable to measure the influence of MIS inquiry on organizational decision making. One approach would be to begin with a given organizational problem, and to then study the subsequent demands for information which are generated, and the resolution of the problem in terms of MIS-based arguments.

More studies of MIS involvement, whether based on the ideas presented here or not, will be welcome. Evidence continues to accumulate on the importance of "involvement," but definitive work is lacking. For example, at the Founding Conference of the Society for Management Information Systems, a questionnaire was administered to 142 participants, asking them to identify the relative importance of 35 separate factors in contributing to "MIS project success." The factor receiving the highest collective ranking was "participation by operating management in design, formal approval of specifications, and continual review of project." [37] We do not know, however, whether the respondents shared a common conception of "project success" or "participation."

Typical of other reports on involvement is a case study reported by Edgar Huse [22]. He concludes that "top management needs to be highly involved in ... design and implementation." And that "installations that have clearly involved their operating personnel in the design as well as the implementation of the systems have tended to be considerably more successful ... than those organizations that have not ...." [22 : 289-94] More than this we do not know.

A more sophisticated study of involvement may be found in the Ph.D. thesis of Ephraim McLean [26]. McLean applied multiple regression techniques to data on the "acceptance and use" of a computer-based medical history system. He found that "desired involvement" and "actual involvement" in the development of the system were the factors (among 20 identified and tested) which most effectively explained the variation in acceptance and use of the system among the physicians. However, exactly what was learned about involvement is not so clear. The measure of "desired involvement", for example, was based on a questionnaire response to the item: "How much involvement would you like to have in the future: ( ) Substantially less than at present; ( ) Less than at present; ( ) About the same as at present; ...." [26 : 142]

Clearly, in order to make any substantive progress in research on involvement, more definitive techniques must be introduced.

As a final suggestion, I would recommend further research on what I have called "techno-proponent groups."[1/] This seems to me a potentially important locus for the study of modern technology-based organizations. In my experience, the formation of and competition between these groups have been vital organizational forces.[2/] The study of these forces thus seems to me to be a fruitful enterprise.

3.3 Concluding Thoughts.

There is a certain irony to this thesis which the reader may or may not have noticed. We have concerned ourselves with the problem of computer-based inquiry in

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1/ Admittedly, not a very attractive name. Perhaps someone can improve upon it. For related, more macroscopic concepts, see Galbraith [20] on organizational "technostructure"; and Emery and Trist [19] on "socio-technical systems".

2/ Particularly in the area of product development. Inter-firm competition is the most visible to the public, but intra-firm battles are every bit as interesting and important. Where technological innovation predominates, the organizational reverberations are often dramatic. (See, for example, the gossip in the computer-trade journal Datamation for a hint of what goes on.)

management information systems. And we have argued that a manager informs himself in this context only to the extent he understands (and is involved with) the system as a whole. Of course, our own research was a form of inquiry. A "scientific" inquiry. We might well ask: was our problem fundamentally different?

Consider. We designed our own "management information system," did we not? It had its own data origination processes: the recording of the MIS inquiry history log and the administration of the research questionnaire. A data base was maintained: the results of our data gathering were summarized into the measures with which we were concerned. And computer programs were used to generate reports which indicated the results of our statistical experimentation: each test might be thought of as a report-producing query. Thus my own computer-based inquiry consisted of the formulation of statistical tests and the interpretation of the reported results.

It seems surely true to me that my statistical inquiry would have produced little "information" apart from my full research involvement. What, after all, could the value of a chi-square statistic indicate, except within the context of the processes which generated it? A statistic is an index like any other,

and while it may be a necessary means to information in situations of complexity (as Kenneth Boulding has eloquently observed[1/]), it is not by itself sufficient. Or so we are arguing.

The reader might protest at this point. After all, he has hardly been involved in my research process! Should he therefore feel uninformed?

Hopefully, not. The presentation of this thesis has attempted to be consistent with its own argument. Thus, the Introduction includes a statement of our research intentions, and a substantial portion of the previous chapter is devoted to a development of the research context. The idea has been to give the reader

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1/ "The ... technique of the social sciences which is almost peculiar to them and which is of great assistance in the perception of complex social systems is the technique of indexing information. This begins in economics with concepts such as the index of the price level or the gross national product. ... The significance of this operation is that it enables us to see some essential characteristics of a very large and complex system. It is probably fundamental to all knowledge processes that we gain knowledge by the orderly loss of information. ... Indexing is a process of filtering out irrelevant information. Thus, the gross national product or the general price level is actually an enormously complex vector of millions of numbers. Indexing reduces this vector to a single scalar component. It does this by subjecting reality to considerable violence, and by throwing away a lot of information which in other contexts may be very interesting. It is necessary to do this, however, if we are to perceive the broad outlines of the system." [8 : 71-72]

a sense of the research perspective, and a feeling for the situation within which the data has originated. This hardly makes the research more "objective", of course. But, then, no research of my design would be!

Churchman's advice is to the point:

> Instead of the silly and empty claim that an observation is objective if it resides in the brain of an unbiased observer, one should say that an observation is objective if it is the creation of many inquirers with many different points of view. [13 : 86]

This thesis represents one such viewpoint; one concept of a management information system. The reader must, in the end, be his own designer and inquirer. That is, he must involve himself in his own (re)search. In this context, perhaps he will find my work informative. After all, while

> The systems approach begins when you first see the world through the eyes of another. [14 : 231]

an appreciation of the view originates with the looking.

Postscript

The following "commentary" by Charles Schulz[1/] seems to me an appropriate "last word" on the subject of management information systems, and I cannot resist including it here:

1/ c 1969. United Feature Syndicate, Inc.

Summary

Chapter 1. Management Information Systems: The Basis for Research

It is argued that MIS designs are often based upon the following ideal:

> The latest vogue in computer information systems is the so-called real-time management information system. The general idea is to have in each executive's office a remote computer terminal which is connected to a large-scale computer with a data bank containing all of the relevant information in the company. The data bank, updated continuously, can be "interrogated" by the manager at any time. Answers to questions are immediately flashed on a screen in his office. Allegedly, a real-time management information system enables the manager to obtain complete and up-to-the-minute information about everything that is happening within the company. [17]

Our thesis asserts that

> A manager is informed through MIS inquiry only to the extent he understands the MIS as a whole.

Attempts to implement the MIS ideal are therefore constrained by the manager's need to understand the "whole system." A body of MIS theory is developed, including the following presuppositions:

(1.1) A manager is an organizational decision-maker responsible for setting objectives, determining plans of action, and evaluating performance.

(1.2) The decision-making process takes place wholly within the context of a world view.

(1.3) A manager is informed to the extent he possesses a realistic world view.

(1.4) The purpose of a management information system (MIS) is to inform managers.

The nature of an MIS is described (see Illustration 1.1) from a process-oriented point of view:

(1.5) The MIS-process consists of five interrelated components:

(i) data origination

(ii) data base maintenance

(iii) report generation

(iv) inquiry

(v) design

It is argued that a manager's involvement with an MIS is the source of his understanding of the system. The concept of "involvement" is defined:

(1.6) A manager is (cooperatively) involved with an MIS to the extent their respective activities facilitate the achievement of

their respective ends. The inquiry involvement of a manager consists of his involvement with the MIS inquiry process. The a priori involvement of a manager consists of his involvement with the MIS design, data origination, data base maintenance, and report generation processes.

The psychological construct, "MIS appreciation," is also defined:

(1.7) The MIS appreciation of a manager consists of a manifold of beliefs about the relative value of the MIS as a means of inquiry.

A model of MIS appreciation and involvement is presented (Illustration 1.2), and three research conjectures are formulated:

(1.8) A priori involvement co-produces (indirectly) inquiry involvement.

(1.9) A priori involvement co-produces MIS appreciation.

(1.10) MIS appreciation co-produces (and is co-produced by) inquiry involvement.

Measurement presuppositions are stated for each of the three conceptual variables.

* * *

Chapter 2. A Study: The SQC Engineering Group and Its Activity Reporting Information System

Field research was undertaken to test the theory developed in the first chapter. Interviews, direct observation, an examination of written communications, a computer-maintained inquiry history log, and the administration of a questionnaire: all were used in the investigation of the SQC Engineering Group and its Activity Reporting Information System ("ARIS").

Two themes which emerged from the ARIS study were:

(2.1) An MIS originates and develops within an evolutionary context, a constantly changing milieu of organizational and technological possibilities.

(2.2) The realization of an MIS is the product of sustained individual and group commitment in an otherwise indifferent (or hostile) social environment.

The three conjectures of Chapter 1 (items 1.8, 1.9, and 1.10) were tested statistically. It was concluded that

(2.3) MIS appreciation co-produces (and is co-produced by) MIS involvement.

but that a revised model of MIS appreciation and involvement would be needed to make further causal statements.

It was noted that

(2.4) MIS involvement is interpersonal as well as personal.

and that our original model failed to take this into account.

A new concept, the "techno-proponent group", was introduced as a byproduct of the study:

(2.5) A techno-proponent group is a social group whose objective is the application of a particular technology to the solution of organizational or social problems.

It was observed that

(2.6) An MIS is the brainchild (design product) of a techno-proponent group.

(2.7) A client group is perceived by the techno-proponent group to be the beneficiary of the MIS.

The techno-proponent group considered a high MIS utilization rate to be a measure of its design success. Thus:

(2.8) The a priori involvement of the techno-proponent group is directed toward motivating the inquiry involvement of the client group.

It was further observed that

(2.9) The techno-proponent group motivates the client group in two ways: (i) by "selling" the MIS; (ii) by raising organizational decision problems which may be addressed by the MIS.

(2.10) The techno-proponent group employs organizational leverage to secure a supportive MIS environment.

These observations reflect the interpersonal dynamics which should be explained in a revised model of MIS appreciation and involvement.

* * *

Chapter 3. Management Information Systems: A Reconsideration

It is argued that "problem situation" cognitions are the variables which must be added to a revised model of MIS appreciation and involvement. Three types of problem situations are identified:

(3.1) An individual may possess three types of interrelated problem-situation cognitions relative to an MIS: (i) a <u>decision problem</u>, the choice between alternative courses of managerial action;

(ii) an inquiry problem, the choice between alternative MIS queries;
(iii) a design problem, the choice between alternative MIS designs.

A revised model is presented (Illustration 3.1), together with a new set of conjectures:

(3.2) Inquiry involvement is co-produced by the cognition of a particular inquiry problem, given an MIS understanding and appreciation.

(3.3) The cognition of an inquiry problem is co-produced by the cognition of a particular decision problem, given an MIS understanding and appreciation.

(3.4) A priori involvement is co-produced by the cognition of a particular design problem, given an MIS understanding and appreciation.

The revised model serves as the basis for a typology of interpersonal MIS involvement (Illustration 3.2), and a final conjecture:

(3.5) The cognition of a decision or design problem by one individual is co-produced by the inquiry or a priori involvement of another.

Future research directions include a testing of our revised MIS theory in other "real world" MIS settings, and an integration of these results into the larger context of organizational decision making.

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